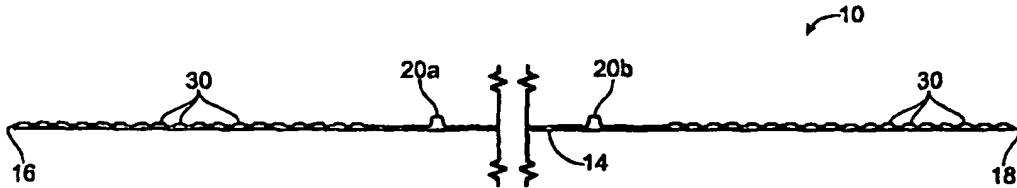




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## (54) Title: BATTERY SEPARATOR WITH IMPROVED SHOULDERS



## (57) Abstract

A battery separator (10) for use in enveloping the plates of a flooded cell type lead acid battery. The separator has improved puncture resistance in the shoulder areas provided by a plurality of improved mini-ribs (30) located therein. The mini-ribs have substantially flat upper surfaces (31), and the space between adjacent mini-ribs is sufficiently small to form regions of high puncture resistance in the shoulder areas. This spacing distance is less than about 0.0225 inch (0.6 mm). The separator may also have a plurality of micro-ribs (40) located on the backside (14).

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## BATTERY SEPARATOR WITH IMPROVED SHOULDERS

### Technical Field

This invention relates to a battery separator for use in flooded cell type lead acid batteries and, in particular, to such a separator that is formed with a shoulder 15 designed to provide improved resistance to puncture.

### Background of the Invention

Separators are used in lead acid batteries to separate the positive and negative plates. Such separators are formed of materials that have sufficient porosity to permit the battery's electrolyte to reside in the pores of the material, thereby permitting 20 ionic current to be established between adjacent positive and negative plates, but not so porous as to allow physical contact between the plates or "treeing" of lead between adjacent plates.

The most commonly used material in flooded cell type lead acid batteries is microporous polyethylene. Such separators and their method of manufacture are, 25 essentially, described in U.S. Patent No. 3,351,495.

Typically such separators have multiple "major" ribs formed on at least that planar face of the "backweb" which is to face the positive plate. Such major ribs are typically formed parallel to the longitudinal edges of the backweb and typically have a height above the backweb that is greater than the thickness of the backweb.

30 Although at one time separators were manufactured as sheets which were placed between the plates, the overwhelming configuration currently used is to wrap the separator material around either the negative or positive plates and seal the

separators, which has a width greater than the wrapped plates, along both edges to thereby form an "envelope" around each wrapped plate. The separator edges adjacent the plate edges, where sealing of the separator is effected, is known as the "shoulder" area of the separator.

5 U.S. Patent No. 4,407,063 discloses the most commonly used method and apparatus for enveloping and sealing separators around plates for lead acid batteries.

One method of making plates for lead acid batteries is to cut, slit, and expand a lead sheet. Such "expanded metal" plates often have sharp metal protrusions, called "bent wires", which can abrade and puncture the adjacent separator shoulder 10 thereby causing a short circuit and premature failure of the battery. Such punctures can occur during enveloping, during battery assembly, or after manufacture of the battery.

One approach to preventing such punctures is to make the shoulder area thicker than the thickness of the adjacent backweb. This approach is disclosed in 15 U.S. Patent No. 4,788,113.

Another approach has been to form "mini-ribs" in the shoulder area. Such mini-ribs have a cross-section that is the arc of a circle. The height of such mini-ribs above the backweb is less than that of the major ribs, typically 0.007 inch (0.18 20 mm). Such prior art mini-ribs are also spaced closer together than the major ribs, a typical such mini-rib spacing being 0.0626 inch (1.6 mm). The use of mini-ribs is preferable over using a thicker shoulder area because of cost considerations. However, it has been found that many punctures still occur in the shoulder area with separators using current mini-rib configurations.

#### Summary of the Invention

25 It is an object of the present invention to provide a separator having an improved shoulder design that greatly reduces puncture by bent wires.

The present invention is a battery separator having a shoulder design that has improved puncture resistance.

30 The separator of the invention has a plurality of mini-ribs extending from one planar face of the separator in the shoulder area, the mini-ribs having a flattened

upper surface rather than the rounded upper surfaces of prior art mini-ribs. The maximum spacing between the mini-ribs of the invention is 0.0225 inch (0.6 mm).

In another embodiment of the invention, a plurality of micro-ribs extend from the planar surface of the separator opposite the planar surface from which the mini-ribs extend.

Additional objects and advantages of this invention will be apparent from the following detailed description of preferred embodiments thereof which proceeds with reference to the accompanying drawings.

#### Brief Description of the Drawings

FIG. 1 is a partial end view of one embodiment of the battery separator of the invention;

FIG. 2 is an enlarged end view of one shoulder portion of the battery separator illustrated in FIG. 1;

FIG. 3 is an enlarged end view of two adjacent mini-ribs of the invention; and

FIG. 4 is a partial end view of another embodiment of the battery separator of the invention using micro-ribs.

#### Detailed Description of Preferred Embodiments

The battery separator 10 of this invention is comprised of a backweb 12 having a first (upper) planar surface 13, a second (lower) planar surface 14, a first edge 16, and a second edge 18. Lower planar surface 14 will also be referred to as the "backside."

A plurality of major ribs 20 are located across the width of separator 10, only the two major ribs 20a and 20b closest to edges 16 and 18, respectively, being shown in FIG. 1. Major ribs 20 are typically disposed longitudinally along the length of separator 10, parallel to each other and to edges 16 and 18. However, major ribs 20 may be located at an angle to edges 16 and 18 (i.e., be diagonally disposed), or may be sinusoidal rather than straight.

Major ribs 20 may have any cross-sectional configuration used in the art, including those configurations disclosed in U.S. Patent 5,679,479. Additional ribs

located in that portion of the separator where the major ribs are located, such as disclosed in U.S. Patent No. 5,789,103, may also be used.

Located between the end ribs 20a and 20b and the edges 16 and 18, respectively, are the shoulder areas of separator 10. A plurality of mini-ribs 30 are 5 located in the shoulder areas. Mini-ribs 30 are longitudinally disposed along the length of separator 10, and are substantially evenly spaced from each other. Although it is preferred that mini-ribs 30 extend from only one planar face of separator 10, they may extend from both planar faces in the shoulder area, and may be staggered so that a mini-rib on one planar surface is located between two mini-ribs 10 located on the other planar surface.

Mini-ribs 30 are preferably disposed substantially parallel to each other and to edges 16 and 18. However, mini-ribs 30 may have other configurations, such as being at an angle to the edges 16 and 18 of separator 10, or be sinusoidal rather than straight.

15 FIG. 3 is an enlarged end view of two adjacent mini-ribs 30a and 30b. As can be seen, mini-rib 30a has a flat apex or upper surface 31a. Flat upper surface 31a is bounded by two upper edges 32a and 33a. The base of mini-rib 30a is bounded by two lower edges 34a and 35a, located at the juncture of mini-rib 30a and backweb 12. Mini-rib 30a has sloping side walls 36a and 37a which extend between upper edges 32a and 33a and lower edges 34a and 35a, respectively. Upper edges 32a and 33a and lower edges 34a and 35a are, preferably, rounded as shown in 20 FIG. 3.

25 Likewise, mini-rib 30b, which is identical to mini-rib 30a, has a flat apex or upper surface 31b bounded by upper edges 32b and 33b, lower edges 34b and 35b, and sloping side walls 36b and 37b.

Currently used mini-ribs have rounded apexes, i.e., the cross-section of such prior art mini-ribs is solely the arc of a circle, typically having a radius of 0.007 inch (0.18 mm).

30 The height of the flat upper surface 31 of mini-ribs 30 above the upper planar surface 13 of the backweb 12 of separator 10 is between about 0.003 (0.008) and

about 0.006 inch (0.15 mm), preferably between about 0.003 (0.08) and about 0.004 inch (0.1 mm). Currently used mini-ribs typically have a height of about 0.007 inch (0.18 mm).

5 The width of the flat upper surface 31 is between about 0.008 (0.2 mm) and about 0.018 inch (0.46 mm), preferably between about 0.010 (0.25) and about 0.012 inch (0.3 mm).

10 The spacing between adjacent upper edges of adjacent mini-ribs 30, i.e., the distance between edges 33a and 32b as seen in FIG. 3, is critical to minimizing puncture resistance in the shoulder area. The present inventors have found that if that spacing is less than about 0.0225 inch (0.6 mm), and preferably between about 0.018 (0.46) and about 0.020 inch (0.5 mm), the vast majority of grid wires will not be able to contact the thinner backweb 12 where puncture resistance is low, but will contact the thicker area occupied by a mini-rib 30, thereby minimizing the ability of the wire to penetrate through the separator 10 in the shoulder area.

15 Currently used mini-ribs typically are spaced apart a distance of 0.0626 inch (1.6 mm), which the current inventors have found is much greater than the cross-sectional size of many grid wires, thereby more easily permitting the grid wire to come into contact with the backweb where penetration is more easily achieved.

20 Another preferred embodiment of the invention is one wherein a plurality of "micro-ribs" 40 extend from the backside 14 of the separator.

25 Micro-ribs 40 are preferably substantially evenly spaced apart across the entire width of the backside 14 of separator 10, and run longitudinally along the length of the separator 10, substantially parallel to each other and to edges 16 and 18. However, the micro-ribs 40 may be disposed at an angle to edges 16 and 18, i.e., be diagonally disposed, or be sinusoidal rather than straight.

30 The cross-section of micro-ribs 40 is preferably the arc of a circle, as can be seen in FIG. 4 which illustrates four adjacent micro-ribs 40a, 40b, 40c, and 40d. The height of micro-ribs 40 above the backside is between about 0.003 (0.08) and about 0.006 inch (0.15 mm), preferably between about 0.003 (0.08) and about 0.004 inch (0.1 mm).

The distance between micro-ribs 40, measured center-to-center, is less than about 0.0225 inch (0.6 mm), preferably between about 0.018 (0.46) and about 0.020 inch (0.5 mm).

5 Example 1 below describes a specific configuration for a battery separator having the mini-rib configuration of this invention.

#### EXAMPLE 1

A microporous polyethylene battery separator was made having the following characteristics:

10	Separator width:	6.4 inches (16.25 cm)
	Backweb thickness:	0.006 inch (0.15 mm)
	Major ribs:	
	Number:	20
	Height:	0.019 inch (0.48 mm)
15	Width:	0.015 inch (0.38 mm)
	Spacing:	0.263 inch (6.7 mm)
	Mini-Ribs:	
	Number:	18 (each shoulder)
	Height:	0.004 inch (0.1 mm)
20	Width:	0.010 inch (0.25 mm)
	Spacing:	
	Upper edges:	0.0225 inch (0.6 mm)
	Centers:	0.0325 inch (0.8 mm)
	Lower edges:	0.0066 inch (1.7 mm)
25	Other:	0.131 inch (3.3 mm) (distance between centers of adjacent major rib and mini-rib)

## EXAMPLE 2

Separators having the configuration described in Example 1 were tested for puncture resistance. The method used for testing for puncture resistance was a modified BCI Test Method 3.214. The modification consisted of substituting a pin 5 having cross-sectional dimensions of 0.0225 inch (0.6 mm) x 0.0325 inch (0.8 mm) for the pin size specified in the original test method. The reason for the substitution of pins was to use a pin which more closely approximated smaller grid wires. The puncture resistance of a large number of Example 1 separators averaged 0.75 pound (1.65 kg).

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## COMPARATIVE EXAMPLE 1

Prior art separators were also tested for puncture resistance using the same modified test procedure used in Example 2. These prior art separators had the same dimensions of the Example 1 separators with the exception that the mini-ribs of such 15 prior art separators were spaced apart a distance of 0.0626 inch (1.6 mm) (center-to-center) and the cross-section of the mini-ribs was the arc of a circle having a radius of 0.007 inch (0.18 mm). The average puncture resistance of a large number of such prior art separators was 0.62 pound (1.4 kg).

While specific embodiments have been described, it is not intended that they 20 restrict the scope of the invention beyond that set forth in the appended claims.

It will be obvious to those having skill in the art that many changes may be made to the details of the above-described embodiment of this invention without departing from the underlying principles thereof. The scope of the present invention should, therefore, be determined only by the following claims.

## Claims

1. A battery separator comprising:
  - 5 a backweb of porous, acid resistant material, said backweb having first and second planar surfaces, first and second edges, and first and second shoulder areas located adjacent said first and second edges, respectively; and a plurality of mini-ribs extending from at least the first planar surface of said backweb in said first and second shoulder areas, adjacent ones of said mini-ribs spaced apart by a distance that is sufficiently small to form in the first and second shoulder areas regions of high puncture resistance.
  - 10 2. The separator of claim 1 wherein said mini-ribs are spaced apart by a distance of less than about 0.0225 inch (0.6 mm).
  3. The separator of claim 2 wherein said mini-ribs are spaced apart a distance of between about 0.018 (0.46) and about 0.020 inch (0.5 mm).
  - 15 4. The separator of claim 1 wherein each of said mini-ribs has a flattened upper surface.
  5. The separator of claim 1 wherein the height of said mini-ribs above the adjacent planar surface of said backweb is between about 0.003 (0.08) and about 0.006 inch (0.15 mm).
  - 20 6. The separator of claim 4 wherein said substantially flat upper surface of said mini-ribs is between about 0.008 (0.2) and about 0.012 inch (0.3 mm) in width.
  7. The separator of claim 5 wherein the height of said mini-ribs above the adjacent planar surface of said backweb is between about 0.003 (0.008) and about 0.004 inch (0.1 mm).
  - 25 8. The separator of claim 1 wherein a plurality of major ribs extend from at least one planar surface of said backweb in the area of said backweb located between said first and second shoulder areas.
  9. The separator of claim 1 wherein a plurality of micro-ribs extend from the second planar surface of said backweb.
  - 30 10. The separator of claim 9 wherein said micro-ribs are substantially evenly spaced across the entire width of said second planar surface.

11. The separator of claim 9 wherein the distance between the centers of said micro-ribs is less than about 0.0225 inch (0.6 mm).
12. The separator of claim 9 wherein the distance between the centers of said micro-ribs is between about 0.018 (0.46) and about 0.020 inch (0.5 mm).
- 5 13. The separator of claim 9 wherein the height of said micro-ribs above the second planar surface of said backweb is between about 0.003 (0.08) and about 0.006 inch (0.1 mm).
14. The separator of claim 13 wherein the cross-section of said micro-ribs is the arc of a circle.

**AMENDED CLAIMS**

[received by the International Bureau on 14 September 2000 (14.09.00) original claim 1 amended; remaining claims unchanged (1 page)]

1. A battery separator comprising:
  - a backweb of porous, acid resistant material, said backweb having first and second planar surfaces, first and second edges, and first and second shoulder areas
  - 5 located adjacent said first and second edges, respectively; and
  - a plurality of non-rounded mini-ribs extending from at least the first planar surface of said backweb in said first and second shoulder areas, adjacent ones of said mini-ribs spaced apart by a distance that is sufficiently small to form in the first and second shoulder areas regions of high puncture resistance.
- 10 2. The separator of claim 1 wherein said mini-ribs are spaced apart by a distance of less than about 0.0225 inch (0.6 mm).
3. The separator of claim 2 wherein said mini-ribs are spaced apart a distance of between about 0.018 (0.46) and about 0.020 inch (0.5 mm).
- 15 4. The separator of claim 1 wherein each of said mini-ribs has a flattened upper surface.
5. The separator of claim 1 wherein the height of said mini-ribs above the adjacent planar surface of said backweb is between about 0.003 (0.08) and about 0.006 inch (0.15 mm).
- 20 6. The separator of claim 4 wherein said substantially flat upper surface of said mini-ribs is between about 0.008 (0.2) and about 0.012 inch (0.3 mm) in width.
7. The separator of claim 5 wherein the height of said mini-ribs above the adjacent planar surface of said backweb is between about 0.003 (0.008) and about 0.004 inch (0.1 mm).
- 25 8. The separator of claim 1 wherein a plurality of major ribs extend from at least one planar surface of said backweb in the area of said backweb located between said first and second shoulder areas.
9. The separator of claim 1 wherein a plurality of micro-ribs extend from the second planar surface of said backweb.
- 30 10. The separator of claim 9 wherein said micro-ribs are substantially evenly spaced across the entire width of said second planar surface.

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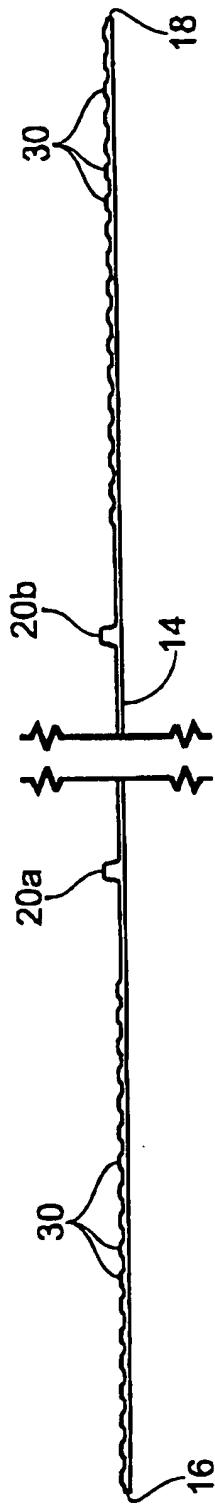


Fig. 1

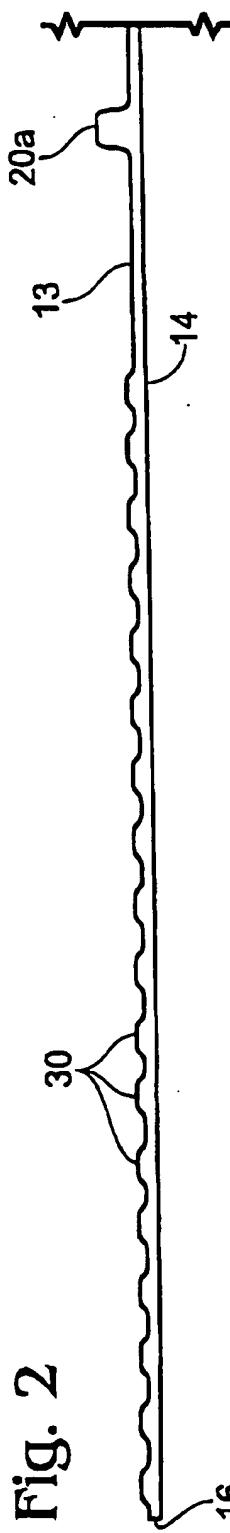
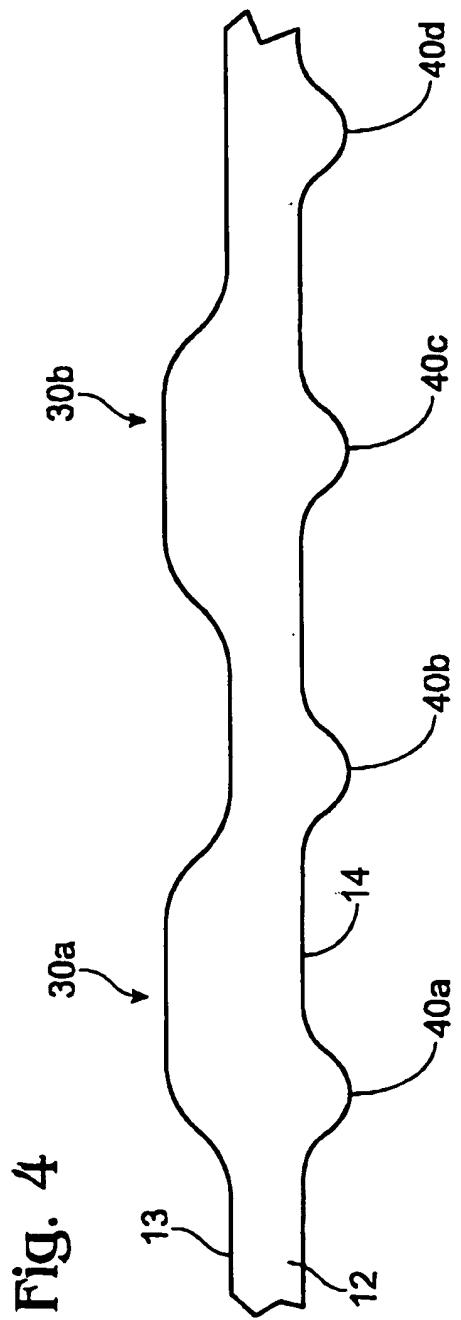
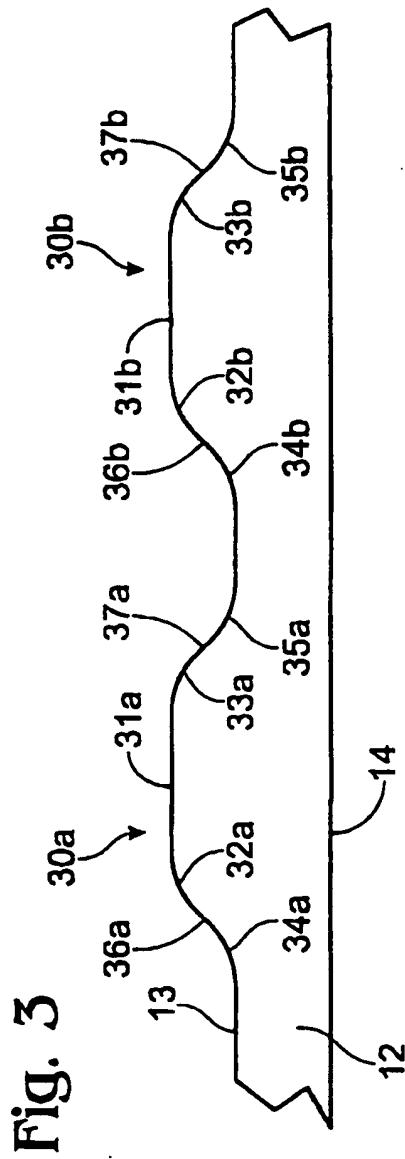


Fig. 2

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## INTERNATIONAL SEARCH REPORT

International Application No  
PCT/US 00/09760A. CLASSIFICATION OF SUBJECT MATTER  
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## B. FIELDS SEARCHED

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IPC 7 H01M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 899 801 A (GEN MOTORS CORP) 3 March 1999 (1999-03-03)	1-3, 8
Y	column 3, line 41 -column 4, line 15 figure 4	9-14
X	US 5 558 952 A (KNAUER DAVIS J) 24 September 1996 (1996-09-24) column 2, line 43-61; figure 1	1
P, Y	US 5 985 484 A (ALEXANDER FRANCIS E ET AL) 16 November 1999 (1999-11-16) column 1, line 37-58	9-14
Y	US 5 894 055 A (ALEXANDER FRANCIS E ET AL) 13 April 1999 (1999-04-13) column 2, line 46-61; figures 1,2	9-14
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Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

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Date of the actual completion of the International search

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**INTERNATIONAL SEARCH REPORT**Inte:  onal Application No  
PCT/US 00/09760**C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT**

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 927 722 A (BOEHNSTEDT WERNER ET AL) 22 May 1990 (1990-05-22) column 3, line 30 -column 4, line 9; figure 1 _____	1-14

## INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 00/09760

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
EP 0899801	A 03-03-1999	US	6001503 A	14-12-1999
US 5558952	A 24-09-1996		NONE	
US 5985484	A 16-11-1999	AU	1469799 A	12-08-1999
US 5894055	A 13-04-1999	AU WO	7102498 A 9847194 A	11-11-1998 22-10-1998
US 4927722	A 22-05-1990	DE AT AU AU DE EP JP JP KR AU	3830728 C 92213 T 617511 B 4008389 A 58905027 D 0358069 A 2168557 A 2983230 B 139206 B 6708390 A	28-12-1989 15-08-1993 28-11-1991 15-03-1990 02-09-1993 14-03-1990 28-06-1990 29-11-1999 15-06-1998 06-06-1991